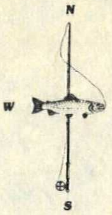
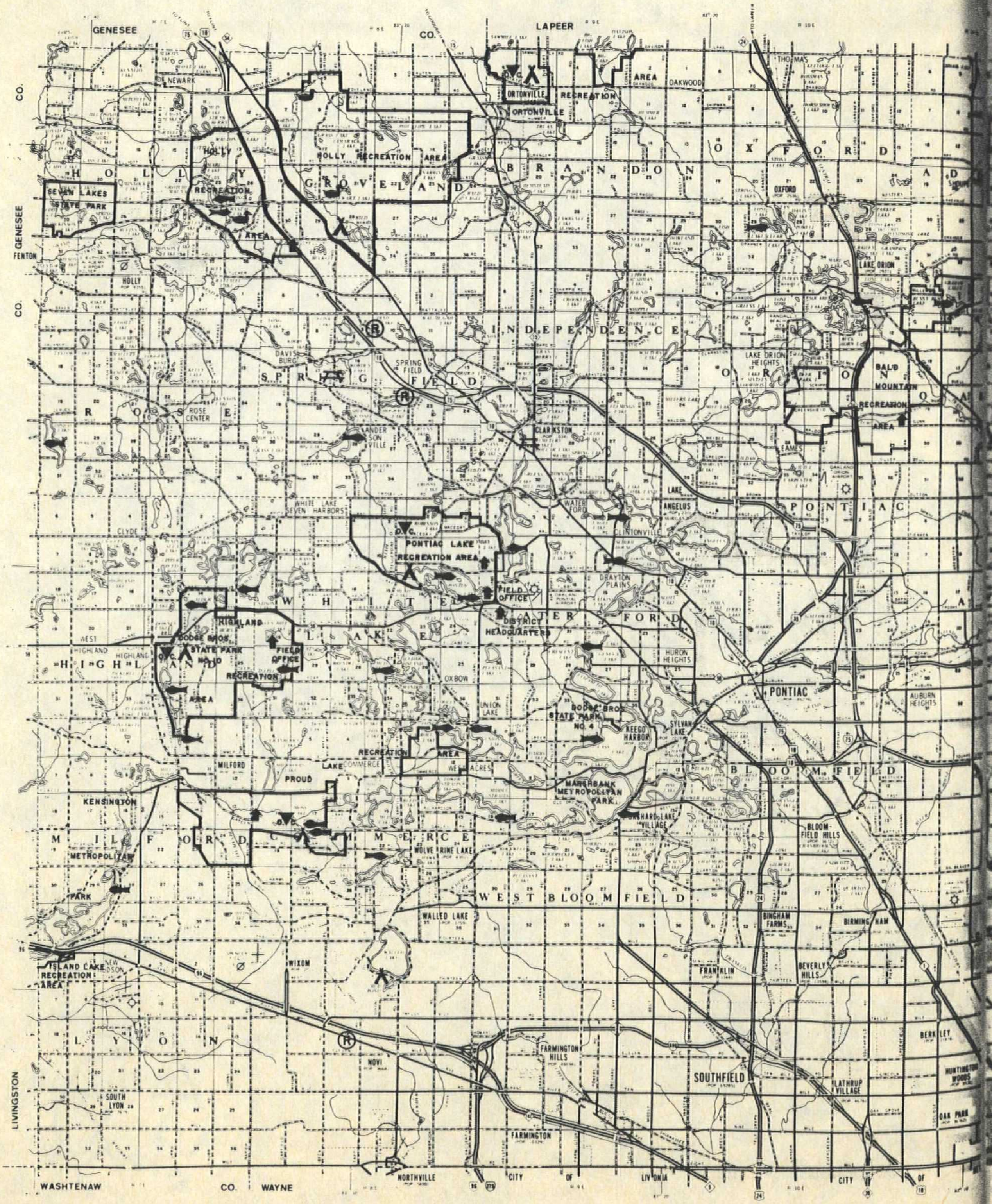
D.6
1980

OAKLAND COUNTY





CHARACTERISTICS OF THE POPULATION

General Population Characteristics

MICHIGAN

1980 Census of Population

U.S. Department of Commerce
BUREAU OF THE CENSUS

HRS 2
Population

Table 14. Summary of General Characteristics: 1980—Con.

[For meaning of symbols, see Introduction. For definitions of terms, see appendixes A and B]

The State Urban and Rural and Size of Place Inside and Outside SMSA's SCSA's SMSA's Urbanized Areas Places of 1,000 or More Counties	Persons													Households		
		Percent								15 years and over—Percent now married, including separated		In group quarters				
	Total	Change 1970–80	Black	Spanish origin	Under 18 years	18 to 64 years	65 years and over	Median age	Fertility ratio	Male	Female	Total	Percent of total persons	Total	Percent change 1970–80	Persons per household
COUNTIES—Con.																
Allegan	81 555	22.5	1.8	2.5	32.0	57.7	10.3	28.5	327	67.3	65.3	1 110	1.4	27 232	39.7	[illegible]
Alpena	32 315	5.2	0.1	0.2	30.8	57.4	11.8	29.4	286	64.7	60.9	415	1.3	11 151	27.1	[illegible]
Antrim	16 194	28.4	0.1	0.4	29.4	55.5	15.1	32.2	325	69.0	65.8	164	1.0	5 723	45.7	[illegible]
Arenac	14 706	31.9	–	1.1	30.7	55.4	13.9	31.3	324	67.4	65.3	100	0.7	5 099	49.7	[illegible]
Baraga	8 484	8.9	0.7	0.4	31.0	53.7	15.3	31.4	376	59.9	63.3	263	3.1	2 929	23.5	[illegible]
Barry	45 781	20.0	0.1	0.9	31.5	58.4	10.1	30.0	314	68.3	67.7	660	1.4	15 433	34.4	[illegible]
Bay	119 881	2.2	0.9	2.6	30.6	59.3	10.1	28.7	302	64.3	59.9	1 094	0.9	41 348	19.6	[illegible]
Benzie	11 205	30.4	0.3	0.9	28.8	56.4	14.8	32.3	291	68.0	63.6	97	0.9	4 008	43.3	[illegible]
Berrien	171 276	4.5	14.5	1.2	30.8	58.3	11.0	29.5	303	64.4	58.8	2 733	1.6	60 276	18.8	[illegible]
Branch	40 188	6.0	0.2	0.6	30.0	58.2	11.8	29.9	312	66.2	62.1	1 012	2.5	14 014	25.0	[illegible]
Calhoun	141 557	–0.3	9.6	1.7	28.9	59.8	11.3	30.4	291	63.6	58.0	4 195	3.0	51 123	15.1	[illegible]
Cass	49 499	14.3	8.4	0.7	30.7	58.4	10.9	30.5	312	67.8	64.9	232	0.5	17 236	29.0	[illegible]
Charlevoix	19 907	20.3	0.1	0.3	30.1	57.7	12.2	30.3	320	66.3	62.6	160	0.8	7 056	41.1	[illegible]
Cheboygan	20 649	24.6	0.1	0.3	30.5	55.5	14.0	31.4	319	68.4	65.3	127	0.6	7 277	47.2	[illegible]
Chippewa	29 029	–10.4	1.3	0.3	27.6	59.9	12.4	29.1	299	58.6	58.5	1 877	6.5	9 931	6.8	[illegible]
Clare	23 822	42.7	–	0.4	28.9	55.6	15.4	33.4	307	70.1	64.8	219	0.9	8 686	62.5	[illegible]
Clinton	55 893	15.3	0.3	1.8	34.5	58.0	7.5	27.6	311	67.0	66.0	192	0.3	17 755	30.5	[illegible]
Crawford	9 465	46.0	0.6	0.5	30.8	56.7	12.5	30.6	344	66.4	65.2	229	2.4	3 315	67.8	[illegible]
Delta	38 947	8.4	–	0.3	31.2	56.1	12.7	30.2	320	65.5	61.7	369	0.9	13 568	25.4	[illegible]
Dickinson	25 341	6.7	–	0.2	27.0	56.1	16.8	33.6	321	67.8	62.3	373	1.5	9 536	21.4	[illegible]
Eaton	88 337	28.2	2.2	1.8	31.5	60.5	8.0	28.3	277	67.0	63.1	1 169	1.3	30 137	51.6	[illegible]
Emmet	22 992	25.4	0.4	0.2	29.2	58.3	12.5	30.1	281	64.2	58.3	642	2.8	8 107	47.4	[illegible]
Genesee	450 449	1.4	17.5	1.7	32.1	59.9	8.0	27.4	294	61.8	56.9	3 746	0.8	154 641	19.2	[illegible]
Gladwin	19 957	48.1	0.1	0.6	29.5	56.2	14.3	32.8	323	70.9	67.7	94	0.5	7 159	70.0	[illegible]
Gogebic	19 686	–4.8	0.7	0.3	24.6	54.7	20.7	39.2	282	62.9	58.0	570	2.9	7 578	6.3	[illegible]
Grand Traverse	54 899	40.1	0.3	0.5	29.3	59.9	10.7	28.8	286	64.1	58.3	1 967	3.6	19 167	67.7	[illegible]
Gratiot	40 448	3.1	0.1	3.3	31.2	57.1	11.7	28.3	318	66.0	60.5	1 765	4.4	13 319	17.5	[illegible]
Hillsdale	42 071	13.2	0.2	0.7	30.3	57.4	12.3	29.6	311	66.9	63.3	1 168	2.8	14 383	26.1	[illegible]
Houghton	37 872	9.3	0.3	0.3	22.9	61.1	16.0	27.4	281	45.0	53.0	3 570	9.4	12 975	17.3	[illegible]
Huron	36 459	7.0	0.1	1.1	30.4	54.5	15.1	31.2	355	67.4	63.9	533	1.5	12 764	23.6	[illegible]
Ingham	275 520	5.5	7.7	3.8	26.2	66.4	7.4	25.3	234	51.9	47.9	21 091	7.7	95 179	23.5	[illegible]
Ionia	51 815	13.0	3.2	1.8	31.8	58.6	9.6	26.3	356	58.3	62.9	3 441	6.6	16 230	26.7	[illegible]
Iosco	28 349	13.8	2.3	0.9	28.6	57.9	13.5	29.2	356	67.2	67.5	1 029	3.6	10 162	38.7	[illegible]
Iron	13 635	–1.3	–	0.2	23.6	54.5	21.9	42.5	318	67.3	61.6	325	2.4	5 430	10.1	[illegible]
Isabella	54 110	21.3	0.9	1.2	24.8	68.1	7.1	22.5	202	47.9	43.4	7 052	13.0	16 044	43.4	[illegible]
Jackson	151 495	5.7	7.2	1.2	29.1	60.9	9.9	29.5	296	61.7	60.2	8 070	5.3	50 974	20.6	[illegible]
Kalamazoo	212 378	5.4	7.5	1.2	26.7	64.4	8.9	27.4	239	57.7	53.1	10 819	5.1	75 405	26.9	[illegible]
Kalkaska	10 952	107.7	–	0.5	32.7	55.6	11.7	29.2	397	70.7	68.9	46	0.4	3 795	117.5	[illegible]
Kent	444 506	8.1	7.1	2.0	29.6	60.2	10.2	28.0	302	62.5	56.3	11 813	2.7	155 598	25.7	[illegible]
Keweenaw	1 963	–13.3	0.5	0.3	20.6	51.7	27.7	46.0	367	62.8	66.9	16	0.8	833	6.0	[illegible]
Lake	7 711	36.2	16.7	0.6	26.7	52.2	21.1	40.4	335	67.9	64.8	5	0.1	3 050	54.0	[illegible]
Lapeer	70 038	33.9	0.2	1.9	35.7	57.2	7.1	26.8	324	67.0	65.1	1 546	2.2	21 202	53.2	[illegible]
Leelanau	14 007	28.8	0.1	0.5	28.5	58.2	13.3	31.9	272	66.3	65.4	104	0.7	5 023	51.0	[illegible]
Lenawee	89 948	10.2	0.8	5.1	31.3	58.5	10.2	29.0	313	66.9	61.6	2 504	2.8	30 044	23.9	[illegible]
Livingston	100 289	70.1	0.5	0.8	34.4	58.6	7.0	28.3	290	66.6	66.8	1 497	1.5	31 344	85.6	[illegible]
Luce	6 659	–1.9	–	0.2	29.2	57.1	13.7	32.2	326	60.0	58.6	538	8.1	2 192	25.5	[illegible]
Mackinac	10 178	5.4	–	0.3	29.9	55.1	15.0	32.3	323	65.6	62.5	86	0.8	3 680	25.0	[illegible]
Macomb	694 600	11.1	1.3	1.0	29.9	62.4	7.7	29.2	249	63.7	59.9	4 447	0.6	229 820	33.9	[illegible]
Manistee	23 019	14.6	0.2	1.4	27.9	56.6	15.6	32.8	279	64.9	60.6	239	1.0	8 490	31.2	[illegible]
Marquette	74 101	14.6	1.7	0.7	28.0	63.1	8.8	26.1	318	57.6	59.7	5 368	7.2	24 514	34.8	[illegible]
Mason	26 365	16.6	0.7	1.4	27.9	57.2	14.9	32.3	315	67.7	63.5	488	1.9	9 693	33.2	[illegible]
Mecosta	36 961	32.0	2.1	0.5	23.3	67.6	9.1	22.8	220	47.2	49.8	5 424	14.7	11 134	42.9	[illegible]
Menominee	26 201	6.6	–	0.2	30.1	55.7	14.1	30.7	351	65.5	63.0	274	1.0	9 283	21.4	[illegible]
Midland	73 578	15.4	0.8	1.1	32.2	60.5	7.3	27.9	295	66.7	64.9	1 604	2.2	24 498	36.0	[illegible]
Missaukee	10 009	40.5	–	0.3	32.2	55.3	12.5	29.6	367	70.8	69.5	32	0.3	3 427	54.6	[illegible]
Monroe	134 659	13.7	1.7	1.3	33.3	58.3	8.4	27.8	320	66.3	63.6	1 289	1.0	43 110	29.8	[illegible]
Montcalm	47 555	19.9	0.2	1.2	31.7	56.1	12.2	29.8	342	68.4	64.8	382	0.8	16 543	33.5	[illegible]
Montmorency	7 492	42.8	–	0.6	27.7	54.5	17.8	36.4	347	71.7	67.9	–	–	2 814	57.9	[illegible]
Muskegon	157 589	0.1	12.2	1.8	30.7	58.6	10.7	28.9	314	63.2	57.9	2 850	1.8	54 526	15.9	[illegible]
Newaygo	34 917	24.7	1.6	1.9	31.6	55.4	13.1	30.9	337	68.8	65.0	260	0.7	12 134	43.7	[illegible]
Oakland	1 011 793	11.4	4.7	1.4	28.7	62.5	8.9	30.3	250	63.7	59.4	10 524	1.0	355 187	34.3	[illegible]
Oceana	22 002	22.3	0.2	5.1	32.4	55.3	12.3	30.0	349	68.1	64.9	265	1.2	7 418	36.4	[illegible]
Ogemaw	16 436	38.1	0.1	0.3	29.1	55.7	15.3	33.3	320	68.7	65.1	253	1.5	5 940	54.4	[illegible]
Ontonagon	9 861	–6.5	–	0.2	30.2	53.9	15.9	34.5	297	63.8	64.5	158	1.6	3 524	9.1	[illegible]
Osceola	18 928	27.6	0.1	0.6	31.8	55.0	13.2	30.5	335	69.0	64.4	191	1.0	6 558	42.5	[illegible]
Oscoda	6 858	45.1	–	0.1	28.1	54.3	17.7	36.6	314	70.8	65.1	107	1.6	2 517	57.7	[illegible]
Otsego	14 993	43.9	–	0.3	32.7	56.4	10.9	29.1	339	67.4	63.2	378	2.5	4 921	62.7	[illegible]
Ottawa	157 174	22.6	0.4	3.2	31.9	59.4	8.7	27.3	315	67.6	64.4	3 724	2.4	50 449	40.4	[illegible]
Presque Isle	14 267	11.1	–	0.3	29.8	55.2	15.0	32.2	341	66.8	65.5	122	0.9	5 008	30.7	[illegible]
Roscommon	16 374	65.5	–	0.4	24.4	56.1	19.4	40.5	293	70.5	67.0	148	0.9	6 519	81.7	[illegible]
Saginaw	228 059	3.8	15.7	5.4	32.6	58.2	9.2	27.6	304	62.6	57.5	3 089	1.4	76 116	20.5	[illegible]
St. Clair	138 802	15.5	2.0	1.5	31.8	57.5	10.7	29.0	306	65.3	60.6	808	0.6	47 308	29.9	[illegible]
St. Joseph	56 083	18.3	2.4	0.7	30.6	57.4	11.9	29.7	344	68.7	64.3	492	0.9	19 794	30.2	[illegible]
Sanilac	40 789	16.9	–	2.1	31.2	54.8	13.9	30.5	340	67.6	65.0	481	1.2	13 959	32.3	[illegible]
Schoolcraft	8 575	4.2	–	0.2	29.5	55.1	15.4	32.4	326	69.0	62.4	106	1.2	3 045	18.7	[illegible]
Shiawassee	71 140	12.8	0.1	1.1	33.7	57.6	8.7	27.7	329	67.7	64.2	434	0.6	23 359	25.7	[illegible]
Tuscola	56 961	17.2	0.6	1.8	33.4	57.0	9.6	28.1	315	66.6	64.1	1 139	2.0	18 290	33.4	[illegible]
Van Buren	66 814	18.9	7.5	2.2	31.6	56.2	12.2	29.7	334	66.6	62.6	646	1.0	23 121	33.9	[illegible]
Washtenaw	264 748	13.1	10.7	1.5	24.2	69.4	6.4	26.3	209	49.8	49.0	21 145	8.0	92 937	35.5	[illegible]
Wayne	2 337 891	–12.3	35.5	2.0	29.3	60.2	10.5	29.3	286	56.0	51.1	29 695	1.3	824 169	–0.8	[illegible]
Wexford	25 102	27.3	–	0.5	30.5	56.3	13.2	30.6	325	69.0	62.6	275	1.1	8 983	44.1	[illegible]

Miguel Ortiz - Secretary
(Mike) Lansing (Central)

Figure 3--Department of Natural Resources
Environmnetal Protection Bureau

GROUNDWATER QUALITY DIVISION
Site Assessment Unit District Responsibilities

These people are all located in Lansing at 517-373-4800 and can be called about specific PA data.

Mason Bldg 4th Fl.

AIR QUALITY DIVISION, 3rd Floor, ~~General Office Building~~ ~~Secondary Complex~~, P.O. Box 30028, Lansing, 48909 517-322-1330

CHIEF, Robert P. Miller. 517-322-1330
Administrative Assistant, Milo D. Smith

Air Programs Branch
Engineering Section Supervisor, Paul Shutt 517-322-1333
Air Quality Evaluation Unit Chief, Barbara J. Gass
Permit Unit Chief, Gerald L. Avery
SIP Revision Unit Chief, Michael J. Koryto
Technical Services Section Supervisor, George C.C. Su . . . 517-322-1339
Air Monitoring Unit Chief, John C. Schroeder
Hazardous Materials Evaluation Unit Chief, John W. Shaffer

Compliance Branch 517-322-1336
Eastern Region
Regional Supervisor, Dennis Drake
Saginaw District Office, State Office Bldg., 411-J E. Genessee St., Saginaw 48607
District Engineer, Mark Reed 517-771-1731
Pontiac District Office, 2455 North Williams Lake Rd., Pontiac, 48054
District Engineer, R. Thomas Maki 313-666-2700
Lansing District Office, General Office Building Secondary Complex, Lansing 48909
District Engineer, Dennis A. Armbruster 517-322-1336
Jackson District Office, 301 E. Louis B. Glick Hwy 4th Floor, Jackson, 49201
District Engineer, Jack H. Larsen 517-788-9598

Western and Northern Region
Regional Supervisor, (Vacant). 517-322-1336
Grand Rapids District Office, State Office Building, 6th Fl., 350 Ottawa, N.W., Grand Rapids 49503
District Engineer, L. J. Holmes 616-456-5071
Plainwell District Office, 621 North 10th Street, P.O. Box 355, Plainwell, 49080
District Engineer, Richard V. VandeBunt 616-685-9886
Marquette District Office, 1990 US-41 South, P.O. Box 190, Marquette 49855
District Engineer, Donald P. Stephens. 906-226-7505
Roscommon District Office, 8717 North Roscommon Road, P.O. Box 128, Roscommon 48653
District Engineer, Ardon W. Toland 517-275-5151

Detroit District Office, 1311 East Jefferson, Detroit 48207
Wayne County Health Department 313-224-4650

BUDGET AND FEDERAL AID, OFFICE OF, 6th Floor, Mason Bldg. P.O. Box 30028, Lansing 48909 517-373-1750

CHIEF, Dennis R. Adams 517-373-1750
Federal Aid Section Supervisor, Timothy D. Trasky
Michigan Land Trust Fund, Executive Secretary, Edward Hagan
Land & Water Conservation Fund, Project Coordinator, Jeanne L. Powers
Land & Water Conservation Fund, Project Coordinator, Mike McDonald
Budget Analyst, Sarah F. Rapp

GEOLOGICAL SURVEY DIVISION, 4th Floor, Mason Bldg
P.O. Box 30028, Lansing, 48909 517-373-1256

CHIEF, R. Thomas Segall 517-373-8014
Assistant Chief, Allen Crabtree 517-373-8517
Oil & Gas, James S. Lorenz 517-373-8760
Production & Proration, Raymond H. Ellison 517-373-8707
Regulatory Control, Samuel L. Alguire. 517-373-9290
Subsurface & Petroleum Geology, D. Michael Bricker 517-373-8220
Economic & Environ. Geology, Robert C. Reed 517-373-8760
Mineral Wells, (Vacant). 517-373-9289
Mining & Economic, Harry O. Sorensen 517-373-8790
Reclamation & Mining Control, Jon Roethele 517-373-9332
Groundwater Geology, Richard P. Bissell. 517-373-7860
Administration Financial Control, Kirk Lindquist 517-373-8517
Office of Compliance, Dorothy Skillings. 517-373-8741

GROUNDWATER QUALITY DIVISION, 8th Floor, Mason Bldg.
P.O. Box 30028, Lansing 48909 517-373-1947

CHIEF, Richard S. Johns 517-373-1947
Administrative Assistant, Ross O. Dodge. 517-373-1947
Permits Section, Section Chief, Wayne Denniston 517-373-8147
Hydro-Geological Section, Section Chief, William Bradford. . . 517-373-0907
Remedial Action Section, Section Chief, Andrew Hogarth 517-373-8448
Compliance #1, Section Chief, Tom Work 517-373-2794
Cadillac District Office, Supervisor, Dan Darnell. 616-775-9728
Grand Rapids District Office, Supervisor, Gerald Heyt. . . . 616-456-5071
Marquette District Office, Supervisor, Earle Olsen 906-226-7505
Plainwell District Office, Supervisor, Galen Kilmer. 616-685-9886
Roscommon District Office, Supervisor, Larry Thornton. . . . 517-275-5151
Compliance #2, Section Chief, David Dennis 517-373-2794
Detroit District Office, Supervisor, Hakimudden Shakir . . . 313-256-1850
Jackson District Office, Supervisor, (Vacant) 517-788-9598
Lansing District Office, Supervisor, Rodney Mosier 517-322-1300
Saginaw District Office, Supervisor, Ron Kooistra. 517-771-1731

* HAZARDOUS WASTE DIVISION, 1st Floor, Ottawa South Office Building,
P.O. Box 30028, Lansing 48909 517-373-2730

CHIEF, Delbert Rector 517-373-2730
Administrative Assistant, Robert Nowinski
Compliance Section
Chief, John Bohunsky
→ Roscommon District Office, 8717 N. Roscommon Rd.,
P.O. Box 128, Roscommon 48653
Supervisor, Tom Polasek 517-275-5151
→ Grand Rapids District Office, 350 Ottawa N.W.,
6th Floor, Grand Rapids 49503
Supervisor, Ronald Waybrant
→ Plainwell District Office, 621 N. 10th St.,
P.O. Box 355, Plainwell 49080 616-685-6851
Supervisor, Tomas Leep 517-373-3710
→ Saginaw District Office,
411-J E. Genesse Street, Saginaw 48607
Water Quality Specialist, James Sygo 517-771-1731
→ Lansing District Office, General Office Bldg.,
Secondary Complex, Lansing 48909
Supervisor, Robert Basch 517-322-1300
→ Detroit District Office,
Supervisor, Kenneth Burda 517-373-2730
Technical Services Section
Chief, Alan Howard 517-373-2730
Facilities Permit Unit, Kenneth Burda
Act 64 Services Unit, Charles Riley
Waste Evaluation Unit, Joan Peck

MICHIGAN DNR DISTRICTS

ENVIRONMENTAL PROTECTION BUREAU

Marquette
Roscommon
Cadillac
Grand Rapids
Plainwell
Lansing-Secondary
Jackson
Saginaw
Detroit Area-~~Unknown at this time~~ Northville

Air Quality, Hazardous Waste, Groundwater Quality, Surface Water Quality,

Community Assistance and Environmental Services are not districted. Offices are based in Lansing.

FYI General overview of Michigan GROUND WATER

MICHIGAN
Ground-Water Resources

Ground water is the source of 17 percent of public-water supplies and nearly 100 percent of the domestic-water supplies in Michigan (Bedell, 1982). Ground water supplies 43 percent of the State's population; however, ground water accounts for only 4 percent of the total water used in the State because most supplies for large urban areas are from surface water, particularly the Great Lakes (Solley and others, 1983; Weist, 1978). Distant from the Great Lakes, water supplies generally are obtained from ground water. Ground-water withdrawal for irrigation is about 37 percent of the total water used for irrigation (Bedell and VanTil, 1979; Solley and others, 1983). Ground-water withdrawals in 1980 for various uses, and related statistics, are given in table 1.

Chemical characteristics of natural ground water in Michigan are determined primarily by the geologic environment through which the water flows. Natural ground water generally is suitable for human consumption and most other uses. Water from glacial deposits, at places, contains large concentrations of iron [2.5–5.0 milligrams per liter (mg/L)]; water from carbonate rocks is likely to be very hard (400–900 mg/L as calcium carbonate); and water from the Saginaw aquifer in the Saginaw Bay–Thumb area commonly is very mineralized (2,000–80,000 mg/L of dissolved solids). Throughout the State, salty water underlies freshwater at depths ranging from about 100 ft in the eastern part of the Lower Peninsula to about 900 ft in the northern part. Average dissolved-solids concentration of water from bedrock (535 mg/L) is about twice as great as the average concentration from glacial deposits (241 mg/L) (Cummings, 1980).

Michigan has identified more than 1,000 sites where ground water has been contaminated to some degree and an even greater number of sites where pollution is suspected (Michigan Department of Natural Resources, 1985). A wide range of contaminants is involved. At many sites, chlorinated hydrocarbons and hydrocarbons that are contained in fuel substances are the contaminants. Nitrates from surface sources have contaminated domestic ground-water supplies in concentrations of as much as 30 mg/L at some locations in the Lower Peninsula (Cummings and others, 1984).

Table 1. Ground-water facts for Michigan

[Withdrawal data rounded to two significant figures and may not add to totals because of independent rounding. Mgal/d = million gallons per day; gal/d = gallons per day. Source: Solley, Chase, and Mann, 1983]

Population served by ground water, 1980	
Number (thousands)	3,978
Percentage of total population	43
From public water-supply systems:	
Number (thousands)	1,310
Percentage of total population	14
From rural self-supplied systems:	
Number (thousands)	2,668
Percentage of total population	29
Freshwater withdrawals, 1980	
Surface water and ground water, total (Mgal/d)	15,000
Ground water only (Mgal/d)	530
Percentage of total	4
Percentage of total excluding withdrawals for thermoelectric power	18
Category of use	
Public-supply withdrawals:	
Ground water (Mgal/d)	220
Percentage of total ground water	41
Percentage of total public supply	17
Per capita (gal/d)	168
Rural-supply withdrawals:	
Domestic:	
Ground water (Mgal/d)	160
Percentage of total ground water	30
Percentage of total rural domestic	100
Per capita (gal/d)	60
Livestock:	
Ground water (Mgal/d)	17
Percentage of total ground water	3
Percentage of total livestock	77
Industrial self-supplied withdrawals:	
Ground water (Mgal/d)	62
Percentage of total ground water	12
Percentage of total industrial self-supplied:	
Including withdrawals for thermoelectric power	1
Excluding withdrawals for thermoelectric power	3
Irrigation withdrawals:	
Ground water (Mgal/d)	77
Percentage of total ground water	14
Percentage of total irrigation	37

GENERAL SETTING

Michigan is divided into two principal physiographic provinces. The Lower Peninsula and the eastern part of the Upper Peninsula of Michigan are in the Central Lowland physiographic province. These areas are underlain by layered sedimentary bedrock of Paleozoic and Mesozoic age. The western part of the Upper Peninsula is a part of the Superior Upland physiographic province, which is underlain by igneous, metamorphic, and sedimentary rocks of Precambrian age. Glacial deposits cover most of the State.

Glacial deposits consist of sand, gravel, silt, clay, and boulders. Sand and gravel, such as in outwash and glaciofluvial deposits, are productive aquifers; mixtures of clay, silt, sand, gravel, and boulders, which form some till deposits, generally are poor aquifers. Lacustrine deposits that are predominantly sand are productive aquifers; those that are predominantly clay yield little or no water. In the northern part of the Lower Peninsula, glacial deposits in some areas are more than 800 feet (ft) thick; in most other areas in the State, the deposits are less than 200 ft thick.

In the Lower Peninsula and eastern Upper Peninsula, bedrock, which underlies glacial deposits and crops out at a few places, consists principally of Paleozoic shale, limestone, and sandstone. These rocks have been deformed into a structural feature known as the Michigan basin (Newcombe, 1933). Sandstone and limestone are productive aquifers and, where near enough to land surface to be recharged by precipi-

Table 2. Aquifer and well characteristics in Michigan

[Ft = feet; gal/min = gallons per minute. Sources: Reports of the U. S. Geological Survey and Michigan Department of Natural Resources, Geological Survey Division]

Aquifer name and description	Well characteristics				Remarks
	Depth (ft)		Yield (gal/min)		
	Common range	May exceed	Common range	May exceed	
Glacial aquifers:					
Outwash and glaciofluvial deposits: Sand and gravel, contains silt and clay in places. Mostly unconfined.	25 - 200	400	1 - 1,000	2,000	Water generally hard; large iron concentrations common; deep wells may produce salty water in places.
Lacustrine sand: Sand, some gravel, and interbedded silt and clay. Mostly unconfined.	25 - 100	200	80 - 500	500	Used for domestic supplies in Saginaw Bay and Detroit areas; is salty in places at depth.
Till: Intermixed clay, silt, sand, gravel and boulders; sand and gravel lenses abundant in some areas. Confined and unconfined.	25 - 200	400	5 - 200	200	Primary source of domestic supply in western Upper Peninsula.
Bedrock aquifers:					
Saginaw Formation: Sandstone, siltstone, some shale, limestone, and coal. Mostly confined.	25 - 300	500	100 - 300	1,000	One of Michigan's most important bedrock aquifers; water generally hard; salty in places at depth.
Marshall Formation: Sandstone and siltstone. Mostly confined or semiconfined, unconfined at places.	25 - 200	400	100 - 500	1,500	Another of Michigan's important bedrock aquifers; salty in places and at depth.
Silurian-Devonian rocks: Limestone and dolomite; some shale and sandstone. Mostly confined.	25 - 150	200	10 - 300	500	Important aquifer in parts of eastern Upper Peninsula; water commonly hard.
Cambrian-Ordovician rocks: Sandstone, limestone, and dolomite. Mostly confined.	25 - 150	200	10 - 100	500	Important aquifer in eastern Upper Peninsula; water commonly very hard; salty in places and at depth.
Precambrian sandstone: Sandstone interbedded with siltstone. Mostly confined.	25 - 400	500	5 - 50	100	Important aquifer in western Upper Peninsula; salty in places.

tation, they produce freshwater. However, where deeply buried, these sedimentary rocks yield brackish or salty water. In some places, this brine is pumped for commercial use.

In the western Upper Peninsula, bedrock consists of Precambrian igneous, metamorphic, and sedimentary rocks. Igneous and metamorphic rocks generally are poor aquifers. Most ground-water production in this area is from glacial deposits and Precambrian sandstone. However, two public-water supplies are from old mine shafts in the igneous and metamorphic rocks.

Annual recharge to unconfined aquifers in Michigan ranges from 3 to 18 inches (in.) and is derived from precipitation which averages 31 in. annually. Some recharge moves to deep aquifers; however, most flows from shallow aquifers to nearby streams and accounts for about 55 percent of the State's streamflow.

PRINCIPAL AQUIFERS

The principal aquifers in Michigan consist primarily of glacial deposits and sedimentary bedrock. Characteristics of the aquifers are described below and in table 2, from youngest to oldest; their areal distribution is shown in figure 1.

GLACIAL AQUIFERS

Lacustrine Sand Aquifers

Lacustrine sand is the major aquifer along Lake Huron northwest of Saginaw Bay and in parts of southeastern Michigan. This material was deposited when lake levels were higher in the Great Lakes basins. Some areas near Saginaw Bay and in southeastern Michigan are underlain by lacustrine clay, which yields little or no water. Dissolved-solids concentrations generally range from 100 to 500 mg/L.

Outwash and Glaciofluvial Aquifers

In the northern and western parts of the Lower Peninsula, outwash and glaciofluvial deposits generally are thick and coarse grained; in most of this area, ground-water supplies are abundant. In the western Upper Peninsula, however, outwash and glaciofluvial deposits tend to be thin and isolated; many wells in this area fail to yield sufficient supplies during periods of less-than-average precipitation. Dissolved-solids concentrations in all areas generally range from 100 to 500 mg/L.

Figure 1. Principal aquifers in Michigan. *A*, Geographic distribution. *B*, Physiographic diagram and divisions. *C*, Generalized cross section (A-A'). (See table 2 for more detailed description of aquifers. Sources: *A*, Farrand, 1982. *B*, Martin, 1936; Raisz, 1954. *C*, Compiled by N. G. Grannemann from U.S. Geological Survey files.)

Till Aquifers

In parts of the western Upper Peninsula, till generally contains lenses and beds of sand and gravel that provide sufficient water for domestic supplies. Elsewhere in the State, till consists of a poorly sorted mixture of rock materials of little permeability. Dissolved-solids concentrations generally range from 100 to 500 mg/L.

Bedrock Aquifers

Saginaw Formation

The Saginaw Formation is an important aquifer in much of the central and eastern parts of the Lower Peninsula. The formation, which is of Pennsylvanian age, is primarily sandstone and siltstone in the Lansing area; it is siltstone and fined-grained sandstone interbedded with shale, limestone, coal, and gypsum in the Saginaw Bay area. Near Lansing, transmissivity of the formation ranges from 130 to 3,300 square feet per day (ft^2/d) depending on differences in degree of fracturing, number of bedding-plane fractures, thickness of the sandstone, and ratio of sand to shale. Sandstone at shallow depths is more permeable than deeply buried sandstone because fractures tend to decrease with depth (Vanlier and others, 1973). The formation is confined in most places. Recharge to the formation is primarily through the overlying glacial and lacustrine deposits. Water of the Saginaw Formation generally is hard; the average dissolved-solids concentration of the water is 1,600 mg/L (Cummings, 1980). Dissolved solids are less (300–800 mg/L) in areas where the aquifer is an important source for municipal supplies such as the Lansing area.

Marshall Formation

The Marshall Formation is one of the most productive bedrock aquifers in the State. The formation, which is of Mississippian age, is composed of siltstone and fine- to medium-grained sandstone. Transmissivity values for the Marshall Formation range from 2,700 to 67,000 ft^2/d (Vanlier, 1966), depending primarily on differences in thickness, size, and number of fractures. Although the Marshall Formation underlies much of the Lower Peninsula, it is used as an aquifer only in the southern part of the Lower Peninsula and in the Thumb area; elsewhere in the Lower Peninsula, water in the Marshall Formation is either too salty for use or other aquifers, closer to the land surface, are used. The formation is unconfined in some locations but generally is confined or semiconfined. Recharge to the formation is primarily through the overlying glacial and lacustrine deposits. Water of the Marshall Formation generally has a dissolved-solids concentration of less than 500 mg/L.

Silurian-Devonian Aquifers

Silurian-Devonian rocks, consisting principally of limestone and dolomite with some shale and sandstone, are aquifers in the northern and southeastern Lower Peninsula and in the southern part of the eastern Upper Peninsula (fig. 1). Transmissivities of these aquifers depend, to a large extent, on the number and interconnection of fractures and solution channels and on thickness. Silurian-Devonian aquifers generally are confined. Recharge to the formation is primarily through the overlying lacustrine deposits. Water of Silurian-Devonian rocks generally has a dissolved-solids concentration of less than 500 mg/L.

Cambrian-Ordovician Aquifers

Cambrian-Ordovician rocks are important aquifers in the east-central part of the Upper Peninsula. The rocks are principally fine- to coarse-grained sandstone in the lower part and limestone and dolomite in the upper part. Transmissivity values for these rocks depend primarily on lithology and thickness. Generally, the aquifers are confined. Recharge to the aquifers is primarily through the overlying glacial deposits. Dissolved-solids concentrations of water from Cambrian-Ordovician rocks range from about 150 to 2,000 mg/L.

Precambrian Sandstone Aquifers

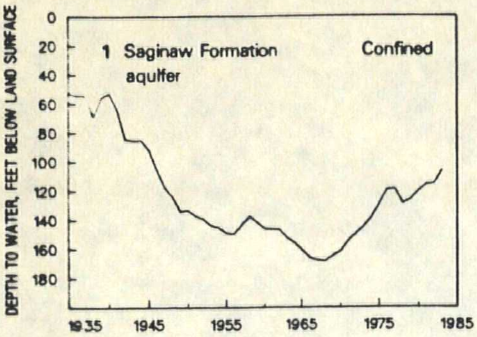
Precambrian sandstones are aquifers only in the northwestern Upper Peninsula where they are used by small communities and for domestic supplies. Because they are well-cemented and interbedded with siltstone and shale, Precambrian sandstones yield water primarily from fractures (Vanlier, 1963). Transmissivity values generally are small. At most places, the aquifer is confined. Recharge to the formation is primarily through the overlying glacial deposits. Dissolved-solids concentrations of water from Precambrian sandstones are generally less than 1,000 mg/L.

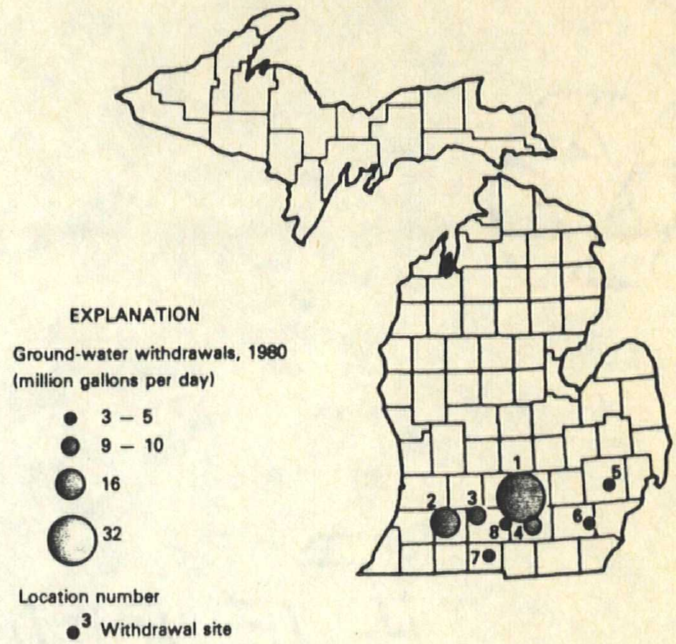
GROUND-WATER WITHDRAWALS AND WATER-LEVEL TRENDS

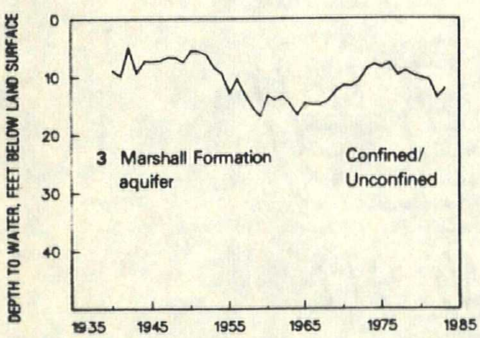
Location of major ground-water withdrawals and trends of ground-water levels near three locations are shown in figure 2. All major pumping centers are in the southern part of the Lower Peninsula; some tap bedrock aquifers, and others tap glacial deposits. Ground water is the source of water for 380 public-water supplies. Of these, 70 communities with a total population of 500,000 obtain water from the Marshall and Saginaw Formations.

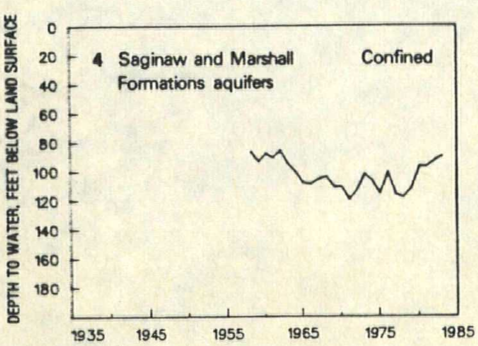
The Lansing metropolitan area withdraws the largest amount of ground water in the State. In 1983, the city of Lansing pumped 8.1 billion gallons (gal) from about 125 wells that tap the Saginaw Formation and unconsolidated glacial deposits. Four other water-supply systems in the area pumped 4.9 billion gal from about 50 wells. Intensive development of ground water in the area has produced a 100-square mile cone of depression. Near the center of the cone, water levels have declined as much as 160 ft.

Water levels generally decline in response to increases in pumping and recover as pumping is reduced. This effect, on a long-term basis, is shown by the hydrograph for Lansing (location 1). During the period of record shown in figure 2, the effects of discontinued pumpage from nearby production wells are shown by a rising water-level trend from 1969 to 1977 in the observation well.









WITHDRAWAL SITES

[Withdrawals are principally for public supply]

No. on map	Geographic area	Aquifer
1	Lansing, East Lansing, Michigan State University.	Saginaw Formation, glacial deposits.
2	Kalamazoo.	Glacial deposits.
3	Battle Creek	Marshall Formation.
4	Jackson.	Saginaw and Marshall Formations.
5	Waterford Township	Glacial deposits.
6	Ypsilanti, Ypsilanti Township.	Do.
7	Coldwater	Do.
8	Albion	Marshall Formation.

Figure 2. Areal distribution of major ground-water withdrawals and graphs of annual greatest depth to water in selected wells in Michigan. (Sources: Withdrawal data from Bedell, 1982; water-level data from U.S. Geological Survey files.)

GROUND-WATER MANAGEMENT

Two State agencies, the Department of Public Health and the Department of Natural Resources, are involved in regulating and managing Michigan's ground-water resources.

The Department of Public Health, through the county health departments, issues permits for domestic and public-supply wells and requires well drillers to submit copies of drilling records to the county health departments. This department also monitors the quality of public-water supplies.

The Department of Natural Resources assists ground-water users by maintaining files of drilling records and by performing hydrogeologic and ground-water-quality studies. The Department also maps and describes geologic formations and monitors mineral wells and subsurface injection of brine.

SELECTED REFERENCES

Bedell, D. J., 1982, Municipal water withdrawals in Michigan: Michigan Department of Natural Resources, Water Management Division, 43 p.

Bedell, D. J., and VanTil, R. L., 1979, Irrigation in Michigan: Michigan Department of Natural Resources, Water Management Division, 37 p.

Cummings, T. R., 1980, Chemical and physical characteristics of natural ground waters in Michigan—A preliminary report: U.S. Geological Survey Open-File Report 80-593, 34 p.

Cummings, T. R., Twenter, F. R., and Holtschlag, D. J., 1984, Hydrology and land use in Van Buren County, Michigan: U.S. Geological Survey Water-Resources Investigations Report 84-4112, 124 p.

Farrand, W. D., 1982, Quaternary geology of Southern Michigan—Quaternary geology of Northern Michigan: Ann Arbor, University of Michigan Department of Geological Sciences, [maps].

Martin, H. M., compiler, 1936, The centennial geological maps of the Northern Peninsula of Michigan—The centennial geological map of the Southern Peninsula of Michigan: Michigan Geological Survey Division Publication 39, Geological Series 33, [maps].

Michigan Department of Natural Resources, 1982, Assessment of ground-water contamination—Inventory of sites: Ground-water Quality Division, Lansing, 242 p.

____1985, Michigan sites of environmental contamination priority list: Groundwater Quality Division, Lansing, 185 p.

Newcombe, R. B., 1933, Oil and gas fields of Michigan: Michigan Department of Natural Resources, Geological Survey Division, Publication 38, 293 p.

Raisz, Erwin, 1954, Physiographic diagram, p. 59, *in* U.S. Geological Survey, 1970, National atlas of the United States: Washington, D.C., U.S. Geological Survey, 417 p.

Solley, W. B., Chase, E. B., and Mann, W. B. IV, 1983, Estimated use of water in the United States in 1980: U.S. Geological Survey Circular 1001, 56 p.

Vanlier, K. E., 1963, Reconnaissance of the ground-water resources of Alger County, Michigan: Michigan Department of Natural Resources, Water Investigation 1, 55 p.

____1966, Ground-water resources of the Battle Creek area, Michigan: Michigan Department of Natural Resources, Geological Survey Division, Water Investigation 4, 52 p.

Vanlier, K. E., Wood, W. W., and Brunett, J. D., 1973, Water-supply development and management alternatives for Clinton, Eaton, and Ingham Counties, Michigan: U.S. Geological Survey Water-Supply Paper 1969, 111 p.

Weist, W. G., Jr., 1978, Summary appraisals of the nation's ground-water resources—Great Lakes Region: U.S. Geological Survey Professional Paper 813-J, 36 p.

Prepared by N. G. Grannemann, F. R. Twenter, G. C. Huffman, and T. R. Cummings

For further information contact District Chief, U. S. Geological Survey, 6520 Mercantile Way, Suite 5, Lansing, MI 48910